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INSTRUMENTATION FOR THE PENSACOLA CENTRIFUGE-SLOW ROTATION ROOM I FACILITY

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JOINT REPORT

UNITED STATES NAVAL SCHOOL OF AVIATION MEDICINE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research Report

INSTRUMENTATION FOR THE PENSACOLA CENTRIFUGE-SLOW ROTATION ROOM I FACILITY *

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SUMMARY PAGE

THE PROBLEM

The original Pensacola Centrifuge installation was modified in 1959 by the addition of a totally enclosed room, identified as "Slow Rotation Room I," about the rotational axis of the device. This room and its associated research and life-support equipments have served as a rotating laboratory where the effects of vestibular stimuli produced by body movements within the environment could be studied under closely monitored conditions. The potential application of data derived from tests performed inside this room to the vestibular problems of manned space operations resulted in a significant increase in the number and scope of the experimental programs carried out aboard the device. Although the limited instrumentation capabilities of the original installation were adequate for its intended centrifuge function, it soon became obvious that they would not satisfy the demands of these additional programs and that a new instrumentation system would be required for their full implementation.

FINDINGS

A new instrumentation system has been developed for the Pensacola Centrifuge-Slow Rotation Room I Facility to meet the specialized demands of the experimentation carried out aboard the device. The design philosophy of the system places emphasis on the ready acquisition of data from any of the on-board experimental areas with particular effort directed toward providing flexibility of operation with minimal loss of research time. Basic design features include expanded data transmission capabilities with computer type patch-panel termination of all basic circuitry; recorders for the display, readout, and storage of experimental data; a closed-circuit television system; and a new console for operational control of the device.

ACKNOWLEDGMENTS

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INTRODUCTION

The original Pensacola Centrifuge was developed in 1944 for the U. S. Naval School of Aviation Medicine by the McKiernan Terry Corporation under the technical supervision of the U. S. Naval Special Devices Center. Its function was to implement research, training, and indoctrination programs concerned with the biological effects of high-level linear accelerations on the operational performance of naval aviators. Using conventional centrifuge operating procedures and techniques, the device well served its intended function from the time of its installation until 1959. At that time, its research capabilities were greatly enhanced by the addition of a totally enclosed room, identified as "Slow Rotation Room I" (SRR-1), about the center column of the device. This room (1) conceived and developed by Captain Ashton Graybiel, MC, USN, of this activity, served as a rotating laboratory where the effects of acceleration stimuli could be readily studied under closely monitored conditions.

As a combined result of the development of this room and the expansion of in-house research efforts to cope with the vestibular problems generated by manned space travel, the work load imposed on the original Centrifuge instrumentation system soon far exceeded its limited capabilities. Particularly prominent was the lack of flexibility which resulted in prolonged down-time of the device whenever it was necessary to change from one instrumentation setup to another, or equally important, whenever it was necessary to move a given instrumentation setup from one on-board experimental area to another. Other shortcomings of the original installation included inadequate communications, operational control, data display, and data storage equipments for the type of research to be performed aboard the device. The system also possessed poor operational reliability due primarily to the age of the component elements, but further complicated by the past application of maintenance and modification procedures which involved a minimal effort approach, not uncommonly referred to as "jury rigging," to the solution of Centrifuge instrumentation problems.

To provide immediate relief from these conditions under restrictive cost limitations, a new instrumentation system was developed for the Pensacola Centrifuge-Slow Rotation Room I Facility with partial financial support afforded by a grant, Order No. R-37, from the office of Life Science Programs, National Aeronautics and Space Administration. Features of the new system include increased data transmission capabilities between each of the on-board experimental areas and the control room data recording equipments; a new console for operational control of the device; expanded audio communications circuitry; the installation of a closed-circuit television system for visual monitoring functions; increased data collection, writeout, and storage capabilities; and the utilization of on-board and control room located patch-panel circuitry for both power and data signals to provide flexibility of operation to the experimenters and ease of circuit-tracing to maintenance personnel. The function of this report is to describe briefly the components of the system used to obtain these features and to outline their relationships to the basic device.

DESCRIPTION OF THE OVER-ALL FACILITY

BASIC DEVICE

The main rotational elements of the device are a bearing supported flywheel and a free-wheeling superstructure mounted immediately above the flywheel which may be friction coupled to either the flywheel or to the fixed building structure by means of an air-actuated clutch mechanism. The flywheel is a laminated steel cylinder approximately 17 feet in diameter, 16 inches thick, and weighing 46 tons. The superstructure is erected on two parallel tubular steel chords which are 40 feet long and spaced 7 feet apart. A steel column of square cross section installed at the midpoint of the line joining the center of the two chords, i.e. the rotational center of the device, supports the upper slip-ring assembly and imparts additional rigidity to the main chords by means of longitudinal interconnecting stringers and struts.

The ten-sided SRR-I enclosure is constructed about this center column and is supported by both the main chords and two semi-circular steel sections welded to the outboard side of the chords. Free swinging cradle assemblies mounted at each end of the main chords (20 foot radius) are used to support the various chairs and cockpit simulators used during more conventional centrifuge applications.

The flywheel is friction driven by a rubber-tired wheel coupled to a Continental Model M336, 6 cylinder L-Head natural gas powered engine through an electrically operated clutch and two cascade mounted gear transmission units. The various gear combinations available provide gross control of flywheel velocity while vernier control is accomplished by a hydraulic controller which activates a governor mechanism that regulates engine speed to within one per cent of any selected value between 1000 and 2000 RPM.

Rotation of the superstructure is established by an air-actuated, brake-shoe clutch assembly which engages the superstructure to the flywheel. The same mechanism is used to stop rotation by declutching from the flywheel and engaging the superstructure to the building structure under controlled stop conditions. An intermediate position of the clutch permits a free wheeling coast to a stop by the superstructure. The pneumatic output of an air-brake controller mounted on the

Operator's Console is routed to the superstructure clutch via a rotary coupling joint installed in the upper slip-ring assembly. The air pressure level set by the controller determines the acceleration rate of the superstructure as it approaches the flywheel velocity, or the deceleration rate of the superstructure as it is brought to a stop. By removing the SRR-I enclosure, easily achieved in one working day, the device may be used in a conventional centrifuge manner with a maximum flywheel speed of 60 RPM. Under these conditions, the onset rate of acceleration capabilities of the device to produce a steady-state g level at the 20 foot radii of the chair cradle assemblies is a function of final flywheel velocity and varies typically from 0.86g/second to reach 2g to 1.48g/second to reach 9g.

BASIC INSTRUMENTATION

A plan view of the operational area of the Centrifuge is shown in Figure 1 which gives the approximate physical location of the major elements of the instrumentation system. In the control room are shown the operator's console which houses the gauges, instruments, indicator switches, and controllers associated with the actual operation of the Centrifuge; the Instrumentation Racks which house the various recorders, amplifiers, test equipments, and patch panels used in the system; and the Monitor Desk used by the principal investigators to program and evaluate the real-time status of their on-going experiments.

Shown aboard the rotating superstructure are the center column above which is mounted the upper slip-ring assembly which electrically interconnects the device to the control room; the center experimental SRR-I test area; the left experimental test area; and the right experimental test area. Also shown are the patch panels mounted on the center column which are used to route the slip-ring circuits to each of the three experimental areas, and the data and power distribution stations installed in each of these areas. The function of these stations is to provide the investigators with a means of terminating their on-board signal-conditioning equipments which allows direct electrical access to the slip-ring circuitry. In each area, individual stations are provided for low-level data signals and for high-level power or control signals. To minimize the generation of electrical noise or interference artifacts during the collection of electrophysiological data, these stations are physically isolated from each other.

A simplified block diagram of the over-all instrumentation system is shown in Figure 2 which outlines the major equipments of the installation and illustrates the routing of the various circuits both on-board the device and in the control room.

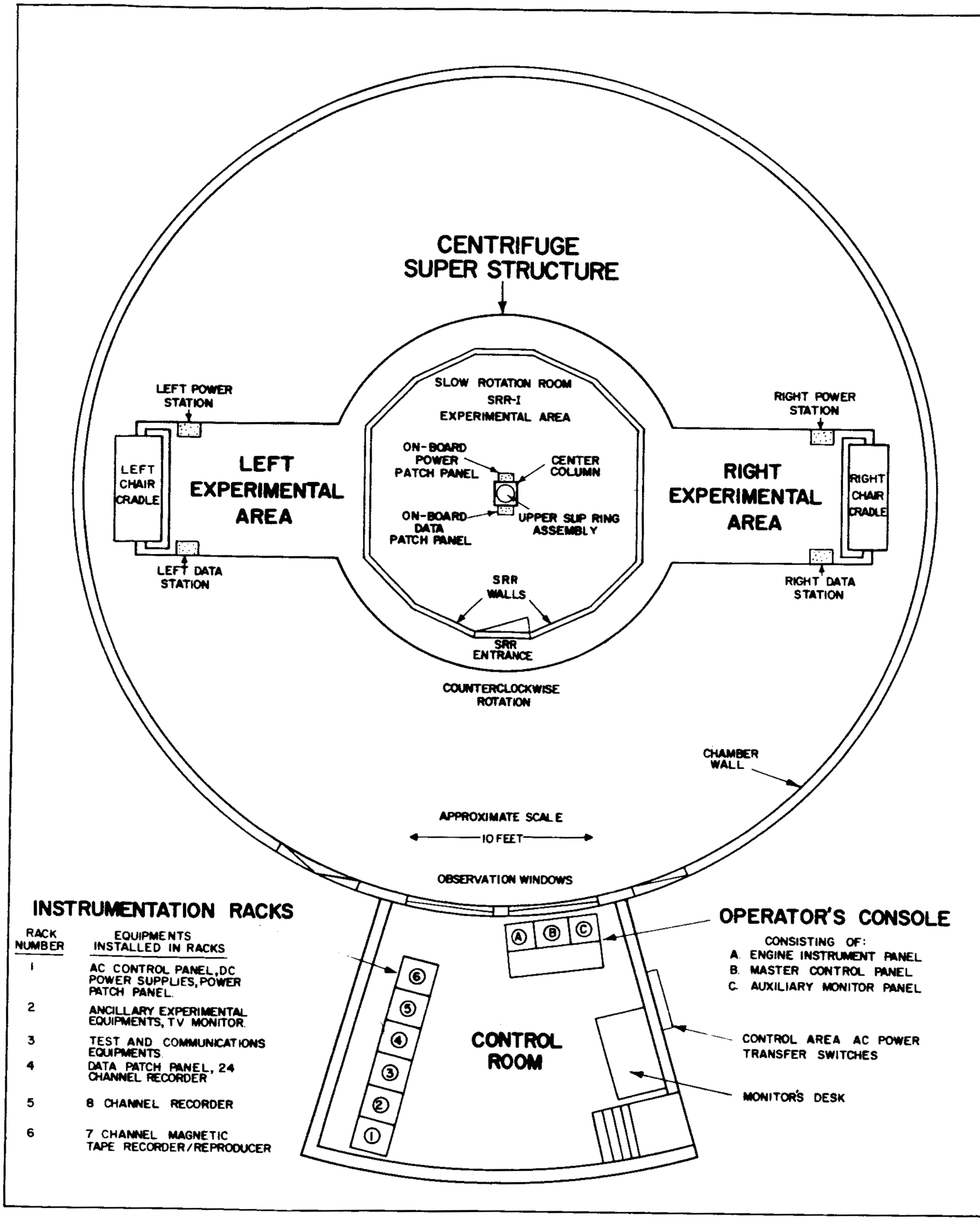

Figure 1

Plan view of the Pensacola Centrifuge-Slow Rotation Room I Facility showing the location of the major instrumentation equipments both aboard the device and in the control room.

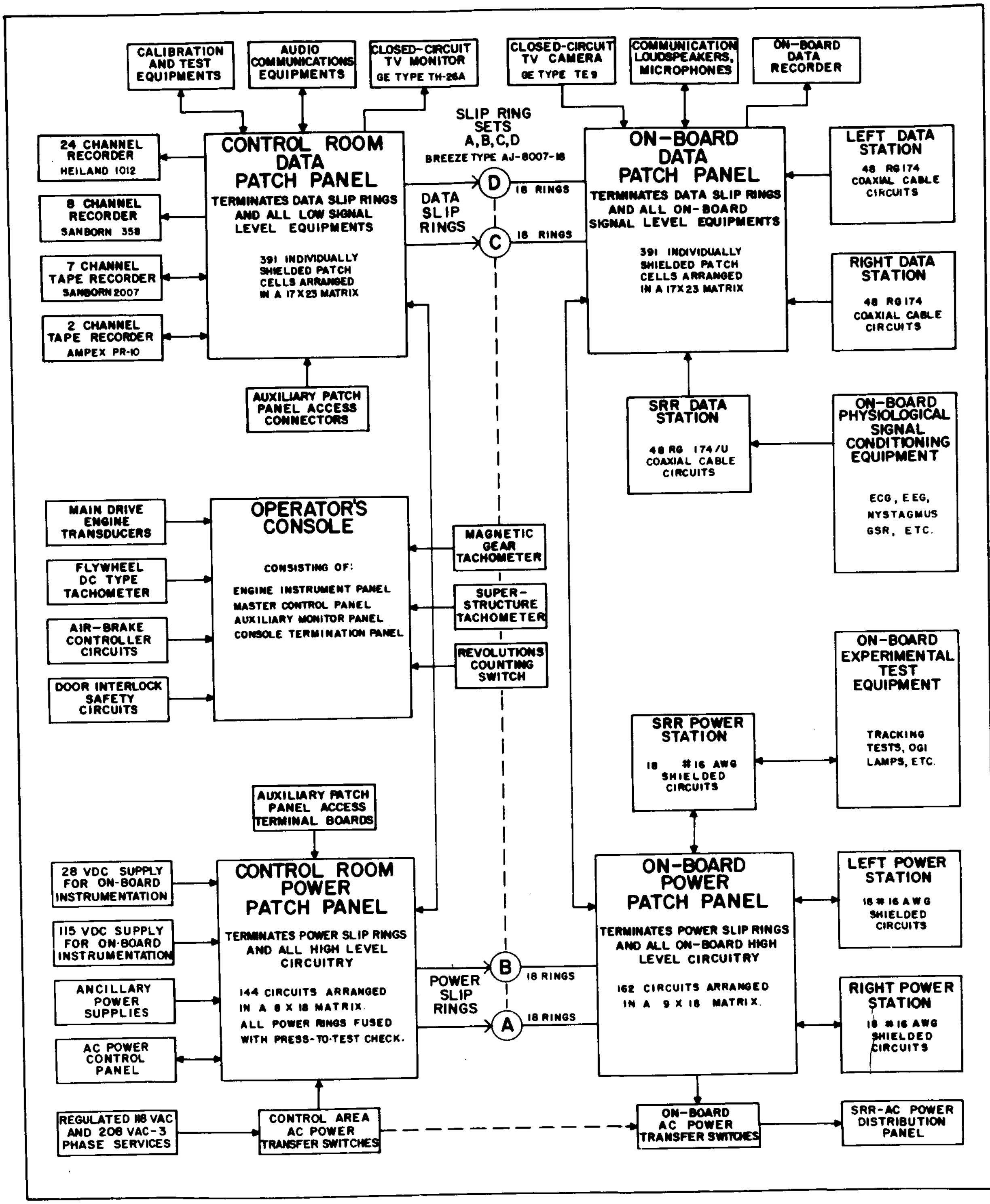

Figure 2

Simplified block diagram of the major elements of the instrumentation provided for the Pensacola Centrifuge-Slow Rotation Room I Facility.

For the transmission of low-level data signals between the device and its control room, two sets of 18-circuit shielded slip rings are provided. The control room end of the rings is terminated in a shielded cell patch panel of the type commonly used in analog computer programming panels. This patch panel also terminates the input and output circuitry associated with the various recorders, communications equipments, test equipments, and TV monitors installed in the system.

An identical shielded cell patch panel mounted on the center column of the device terminates the on-board end of the data slip rings as well as related communications, TV, and recording equipments. This patch panel also terminates a set of access connectors installed on the front panel of the SRR-I Data Distribution Station. These connectors allow the investigators to electrically connect their signal-conditioning equipments, such as ECG, EMG, EEG, and nystagmus preamplifiers, to the patch panel where their output signals may be routed to the control room recording equipments. Identical data stations located in the left and right experimental areas allow the use of signal-conditioning equipments wired for termination inside the SRR-I to be used for experimentation in these areas without any wiring changes other than a reassignment of the patchcords inserted into the patch panel.

A similar approach is used for the transmission of high-level power or control signals to and from the device. As noted in Figure 2, the Control Room and On-Board Power Patch Panels utilize a matrix of color-coded nylon binding posts for the patch terminations. The DC power supplies used for control relays and on-board instrumentation equipments along with the 208 VAC, 3 phase, 4 wire service, and the 118 VAC regulated service are routed through these patch panels. As with the data signals, separate power distribution stations, physically separated from the data distribution stations, are installed in each of the three experimental areas to provide electrical access to the power slip-ring circuitry. To prevent slip-ring damage arising from excessive current loads which could occur during the setup of new equipment aboard the device, transfer switches are provided which allow the slip rings to be bypassed by a hard-line extension cable when the device is not rotating.

Also shown in Figure 2 is the Operator's Console and its interconnections with the main drive engine transducers, the flywheel tachometer, the air-brake controller circuits, the door interlock safety circuits, the two patch panels installed in the control room, the superstructure tachometer, a micro-switch assembly to count the revolutions of the superstructure, and a 600 tooth gear assembly with a magnetic proximity transducer to measure RPM with an events-per-unit-time electronic counter. The latter three units are integral to the upper slip-ring assembly which is mounted at the center of the device. This assembly, as well as the general configuration of the SRR-I enclosure and the left outboard experimental area, is shown in Figure 3.

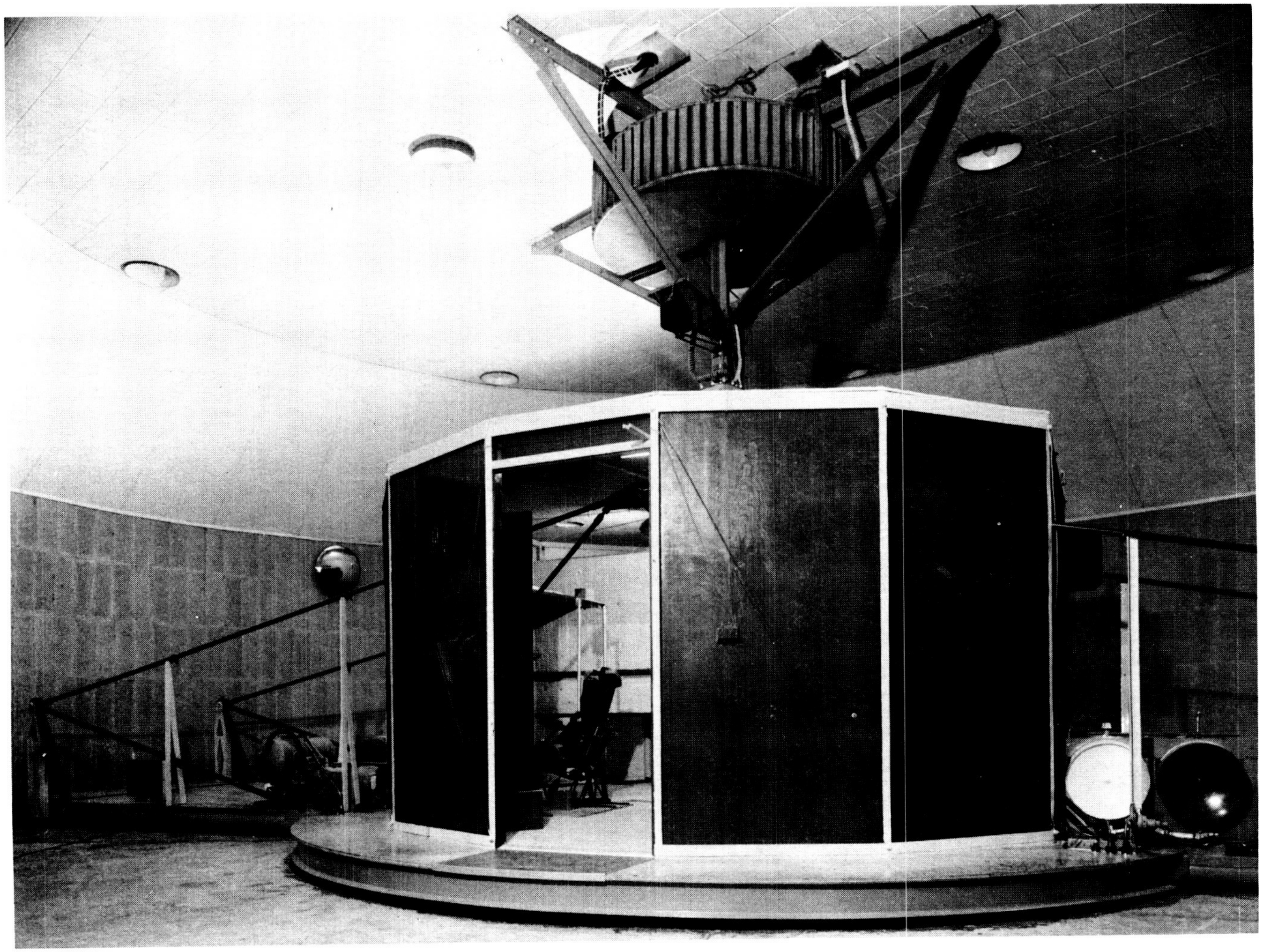

Figure 3

Photograph of the chamber area of the Pensacola Centrifuge–SRR I Facility showing the general configuration of the SRR–I enclosure, the left outboard experimental area, and the upper slip-ring assembly.

DESCRIPTION OF THE INSTRUMENTATION SYSTEM

To define the control and data acquisition capabilities of the instrumentation system separately, the installation is described in terms of the equipments and circuits terminated at the Operator's Console and the Instrumentation Racks. The first section deals with the equipment components installed in or terminated at the Operator's Console which are directly related to the operational control of the device and its drive system. The second section deals with the equipment and circuitry components of the Instrumentation Racks installed in the control room and their interrelationships with the on-board data acquisition elements of the system.

OPERATOR'S CONSOLE

A photograph of the Operator's Console which is installed in the control room is shown in Figure 4. At the center rear is the Master Control Panel which houses

Figure 4

Over-all view of the Operator's Console located in the control room the indicators and switching circuitry associated with the operation of the device. At the left rear is the Engine Instrument Panel which contains the gauges and meters used to monitor the performance of the main and the auxiliary drive engines. The blank panel at the right rear is used to house custom constructed monitor equipment that may be required for specific research projects. The main engine governor controller and the air-brake controller are located to the left and right, respectively, of the center front console module.

The top sub-panel on the Engine Instrument Panel is for the main drive engine and contains an ignition switch, engine speed tachometer, engine running time meter, and gauges for oil pressure, oil temperature, water temperature, battery voltage, and battery current. The bottom sub-panel is for the auxiliary engine and contains an ignition switch, engine speed tachometer, engine running time meter, and gauges for oil pressure, water temperature, and battery current. Duplicate gauges for the oil pressure, water temperature, and battery current are provided at each of the engine installations.

A close-up view of the Master Control Panel is shown in Figure 5. The meters

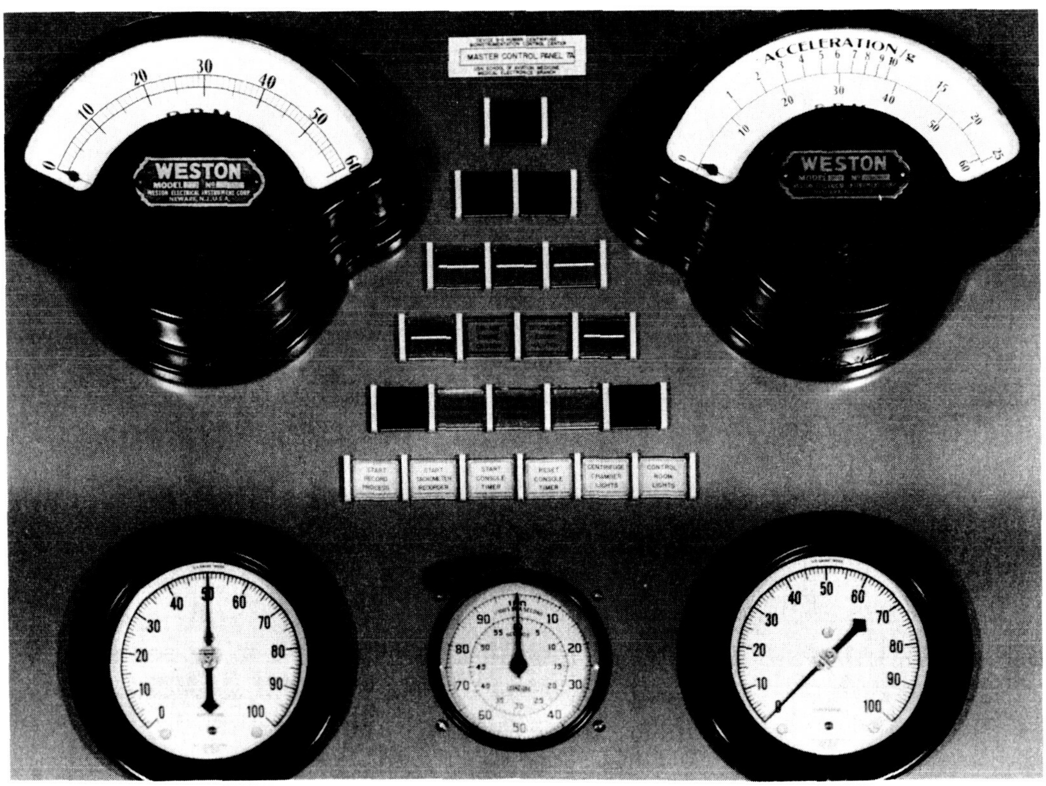

Figure 5

Close-up view of the Master Control Panel showing the tachometer indicator, reset timer, air-brake pressure meters, and indicator lamp-switch assemblies.

at the top left and top right are tachometer indicators for the angular velocity of the Centrifuge flywheel and Centrifuge superstructure, respectively. The latter meter is also calibrated for a direct readout of radial acceleration in g-units. The meters at the bottom left and bottom right of the same panel indicate the air pressure of the input supply line and output feed line, respectively, of the air-brake controller used to engage the superstructure to the flywheel or to bring it to a stop. An electrically controlled reset timer is mounted at the bottom center of the panel. The rectangular switch units arranged in the form of a triangle are combination indicator lamp push-button switch assemblies with inscribed legends inserted under their color-coded plastic face covers.

The switch at the apex of the triangle is used to sound an alarm bell in case of an operational emergency. A similar switch installed in the On-Board Power Patch Panel serves the same function. The two assemblies immediately below this switch are associated with the air-brake safety interlock circuits used to prevent rotation of the superstructure if all checklist procedures have not been completed. The indicator-switch at the left is inscribed with the legend "On-Board Checklist Not Completed" and is wired in parallel with an identical switch located in the On-Board Power Patch Panel. The lamp in this indicator must be turned off by an on-board individual pressing the integral switch which then signifies to the Control Room Operator that the on-board personnel have completed their pre-run checklist and are ready to rotate.

When the related Master Control Panel lamp is turned off, and the Control Room Operator has completed his pre-run checklist, he then presses the adjacent switch, inscribed with a "Control Room Checklist Not Completed" legend, which turns off the internal lamps. If the left chamber, right chamber, and flywheel room doors are all secured, the air-brake controller may be used to start rotation. The three indicator-switches in the third row separately indicate the open or closed status of each of these doors. The switch element of each of these units can be depressed to operate a momentary action solenoid installed in each door frame to allow the related door to be opened.

The above mentioned switches operate relays which control a solenoid valve installed on the output side of the air-brake controller. Whenever this solenoid valve is energized, air pressure from the air-brake controller may be applied to the on-board air-activated clutch which allows the superstructure to be engaged to the rotating flywheel which then initiates rotation. Whenever this solenoid is de-energized, the feed line to the clutch is opened and the output air pressure of the air-brake controller is bled off at the console, thus bringing the superstructure to a stop.

The interlock circuitry is such that, unless all three doors are secured and the "On-Board Checklist Not Completed" and "Control Room Checklist Not Completed" pushbutton switches are sequentially operated, the solenoid bleed valve will be de-energized and rotation cannot occur. If by accident one of the doors is opened while the superstructure is rotating, the valve will be de-energized and the device brought to a stop. Additional interlock circuitry prevents the doors from being opened by the Console Operator unless the air-brake controller is in its stop position.

In the fourth row of switch units are lamps to indicate normal or abnormal oil pressure and water temperature of the drive engine, and pushbuttons to engage or disengage the electrical clutch used to couple the output shaft of the drive engine to its cascaded gear box transmissions. The units in the fifth row select various full scale readings and polarities for the tachometer indicators installed in the Master Control Panel. The bottom row of switches are for ancillary control functions such as starting and stopping the reset timer and tachometer recorder, and turning the control room and chamber ambient lighting on or off.

All electrical connections to and from the Operator's Console including the Engine Instrument Panel and Master Control Panel are terminated at the Console Termination Panel installed in the bottom of the front left console module. These connections are made by means of 0.053 inch taper pins inserted into the rear of 20-circuit taper pin terminal blocks. Each circuit provides three commoned taper pin receptacles with both front and rear access. Interconnections are made by means of jumper cables inserted into the front of these terminal blocks.

INSTRUMENTATION EQUIPMENTS

A photograph of the instrumentation racks installed in the control room is shown in Figure 6. For reference purposes, these units are identified as Racks 1 through 6 from left to right as viewed from the front. Regulated 118 VAC, obtained from a remotely located harmonic neutralized constant-voltage transformer, is used to energize the equipments installed in these racks with individual power control provided by a switch-fuse-indicator lamp combination installed at the very top of each rack. All rack-to-rack wiring is routed through and between two longitudinal aluminum channels used as a support base for the racks.

Relay Rack 1 houses the equipment and circuitry related to supplying the on-board devices with the proper DC and AC power services via the two sets of 18-circuit power slip rings. At the very top of the rack is the AC Control Panel, shown in greater detail by Figure 7, which controls and monitors the two basic AC services supplied to the centrifuge. One service provides 208 VAC, 3 phase, 15 ampere, 4 wire feed, while the second provides a regulated 118 VAC, 10 ampere, 2 wire feed obtained from the same source used to energize the racks. The outputs of the

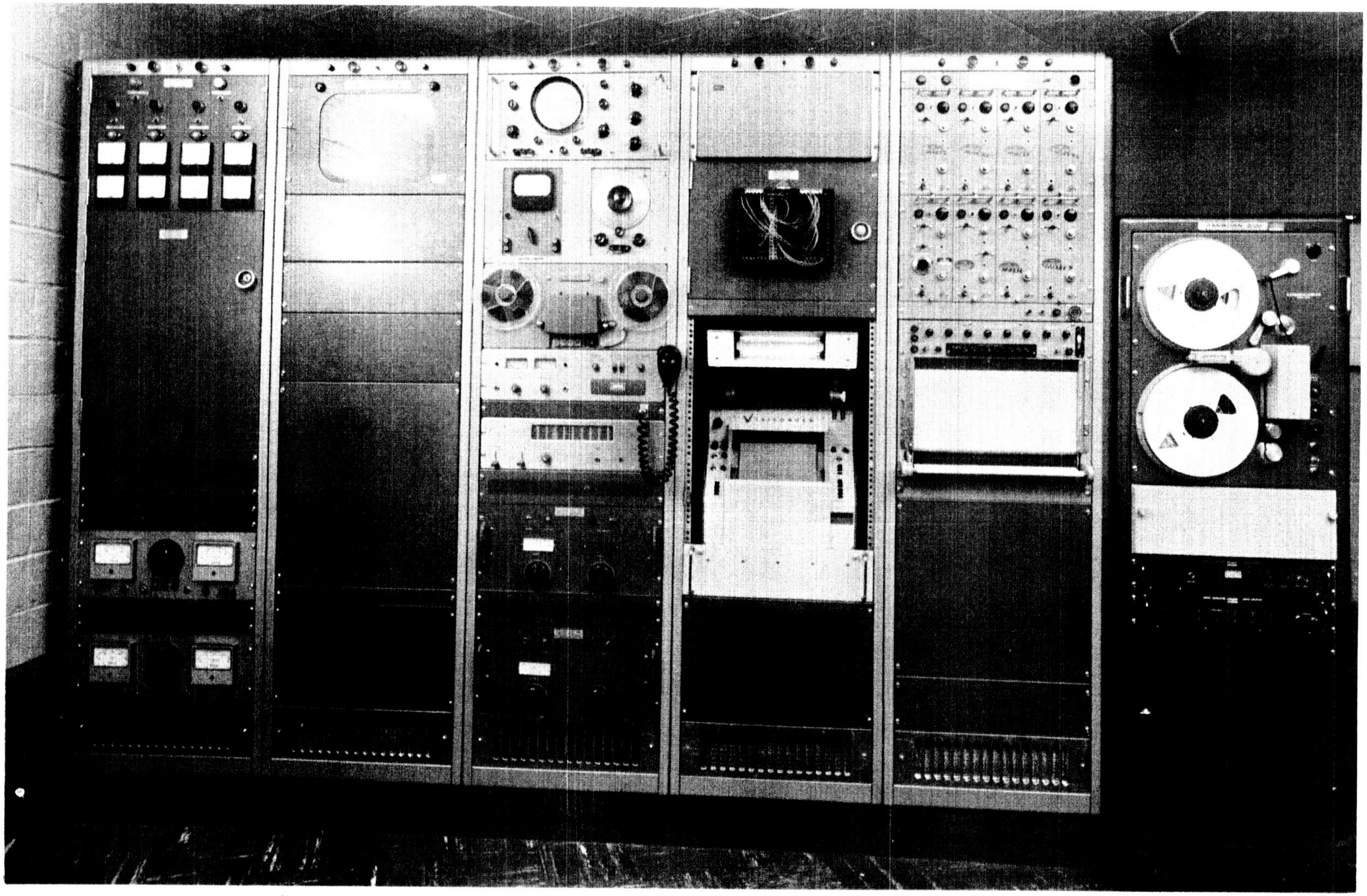

Figure 6

Photograph of the instrumentation racks installed in the control room.

three phases of the 208 VAC service and the regulated service are monitored by individual ammeters and expanded scale voltmeters. The two power supplies installed at the bottom of Rack 1 supply 28 VDC and 115 VDC to control and instrumentation equipments installed both in the control room and on-board the device. A blower fan installed immediately beneath these units provides pressurized ventilation of the racks.

Immediately behind the hinged panel installed below the AC control panel is the Control Room Power Patch Panel which terminates the two sets of 18-circuit power slip rings identified as A and B. This unit, a photograph of which is shown in Figure 8, serves to terminate individually each slip-ring circuit and to provide patch panel type access to these circuits by means of binding posts connected to terminal boards installed behind the unit.

The panel is composed essentially of ten columns of 18 color-coded nylon binding posts and two columns of 18 fuse-switch-lamp combinations. The columns to the left of the center vertical legend plate, inscribed with the numerals 1 through 18, are associated with slip-ring set A while those to the right of this plate are related to slip-ring set B. An individual fuse is provided for each slip ring along with a switch and press-to-test lamp which allows the fuse to be tested for continuity. The switch removes the fuse from the slip-ring circuitry and places it in series with a lamp energized from a 28 VDC source. Since the flexibility of a patch system preempts the predetermination of the potential present on a given slip ring, the isolation feature of the fuse-test circuitry is mandatory.

Several columns of the binding posts are used to terminate circuits which are used on a more or less permanent basis for each experimental setup. Such circuits include the 208 VAC and 118 VAC services, the 28 VDC supply line, and on-board checklist switches. Other columns are connected to rear panel terminal boards which are connected in turn to equipments constructed for specific experiments. With the patchcord interconnection of these binding posts, the equipment related to several different experiments can be simultaneously connected to the system. Thus re-routing of patchcord assignments is the only circuit change required when transferring from one experimental setup to another.

The output of the Control Room Power Patch Panel is routed to the superstructure via the slip-ring assembly installed atop the center column of the device. This assembly, a photograph of which is shown in Figure 9, is composed of four stacked 18-circuit slip-ring brush modules. The top two modules are for the high-level power or control signals. Contact with each of the even-numbered rings is established by two sets of brush contact assemblies mounted adjacent to each other with a 90 degree spacing. Each brush contact provides two spring loaded contact fingers for a total of four conducting points on each slip ring. Two brush contact assemblies similarly

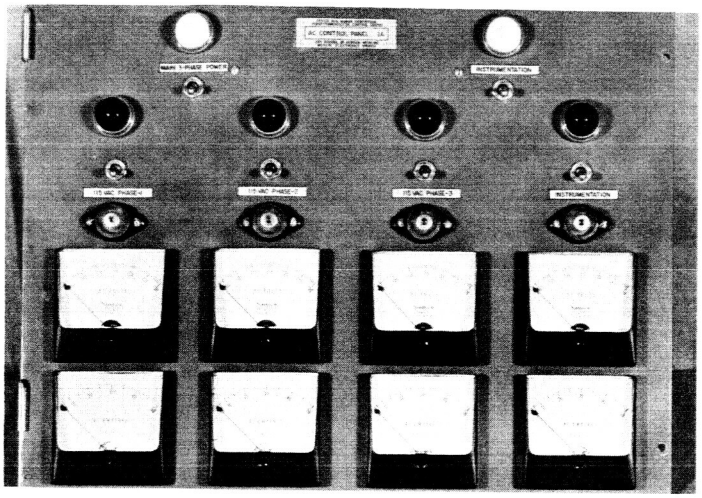

Figure 7

Photograph of the AC Control Panel used to monitor and distribute the AC power services supplied to the system.

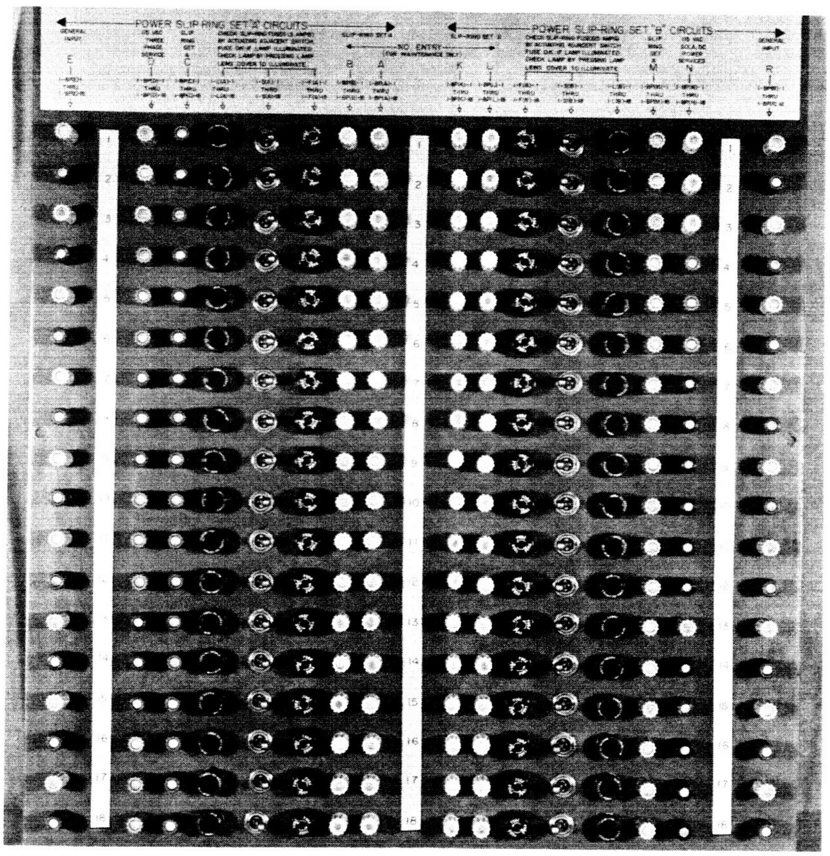

Figure 8

Photograph of the Control Room Power Patch Panel before its installation in Rack 1. The two sets of 18-circuit power slip rings are terminated at this unit as well as the various AC and DC power services furnished to the device.

mounted on 90 degree centers terminate the odd-numbered slip rings. To minimize the generation of electrical noise due to rotational eccentricities of the slip rings relative to the brush holders, the latter are ball-bearing coupled to the upper and lower portions of the slip-ring shaft. Rotation of the brush holders is prevented by a simple universal joint fixed to the building and joined to the brush holders at a single point.

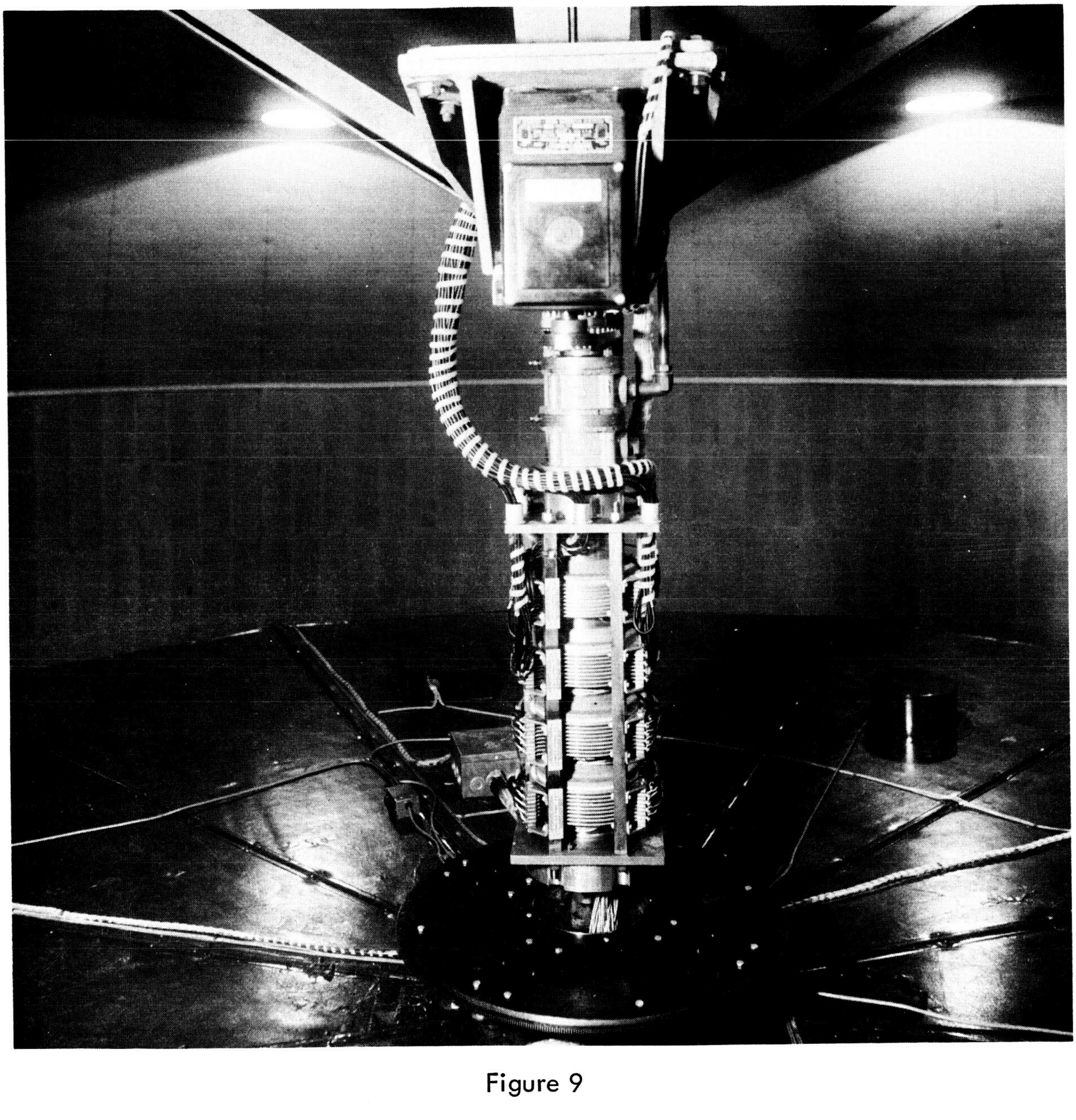

Figure 9

Close-up view of the upper slip-ring assembly showing the four stacked 18-circuit slip-ring brush modules.

The two 18-circuit lines from the power slip rings are run to the On-Board Power Patch Panel, a photograph of which is shown in Figure 10, and separately terminated on two colums of binding posts. This unit, mounted on the center column of the device inside the SRR-I enclosure, is similar in layout to the Control Room Power Patch Panel except for elimination of the press-to-test fuse circuitry. One set of slip rings is patched to a column of binding posts which terminates the input lines to the on-board receptacles used to supply AC and DC power service to the experimental areas. To provide electrical access to the second set of power slip rings, a feed line of 18 #16 AWG shielded lines is run to each of the three experimental areas. For the SRR-I area, these circuits are terminated at a multi-contact connector mounted at the top of the On-Board Power Patch Panel. Similar connectors terminate the circuits at each of the outboard experimental areas. A photograph of the unit used to house the connector installed in the left experimental area is shown in Figure 11. In addition to the multi-circuit connector, receptacles are available for the supply of 28 VDC, 115 VAC unregulated, and 118 VAC regulated to the area. An identical unit is mounted in the right experimental area.

For distribution of AC power aboard the device, the output of the slip-ring circuits associated with the 208 VAC service and 118 VAC regulated service is separately routed through two DPDT transfer switches, located immediately beneath the On-Board Power Patch Panel, to an AC Distribution Panel installed at the base of the center column. When the arms of these on-board transfer switches, along with the arms of two identical transfer switches mounted adjacent to the control room, are placed in the up position, the outlets installed in the AC Distribution Panel are energized through the slip-ring service. When the arms of the switches are placed in the down position and extension cables are connected between the control area and on-board transfer switches, the slip rings are bypassed and power is obtained directly from the control room sources.

This feature permits the setup of new equipment on the centrifuge when it is not rotating without the hazard of slip-ring damage due to malfunctions occurring during an initial test phase. Since identical feed points are used for each AC source, regardless of whether the service is obtained via the slip rings or extension cables, the system allows the checkout of on-board electrophysiological equipment for ground-loop problems under identical conditions. To minimize 60 CPS and similar noise artifacts, shielded cable is used for all wiring aboard the device including the lighting and ventilation circuits.

Returning to Figure 6, note that a 14-inch closed-circuit television monitor is shown at the top of Relay Rack 2. This monitor, along with a portable 14-inch monitor mounted above and to the right of the Operator's Console, is used to display various actions and behavorial responses of on-board personnel. A tripod mounted television

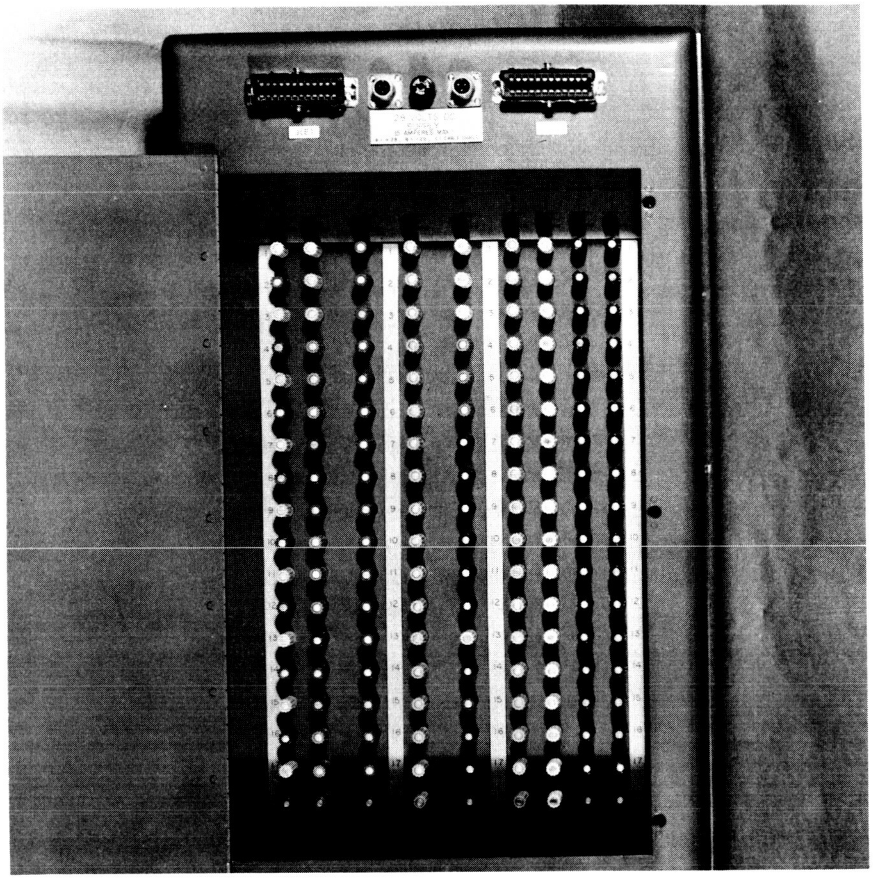

Figure 10

Photograph of the On-Board Power Patch Panel used to distribute the slip-ring power and control circuitry to each of the three experimental areas.

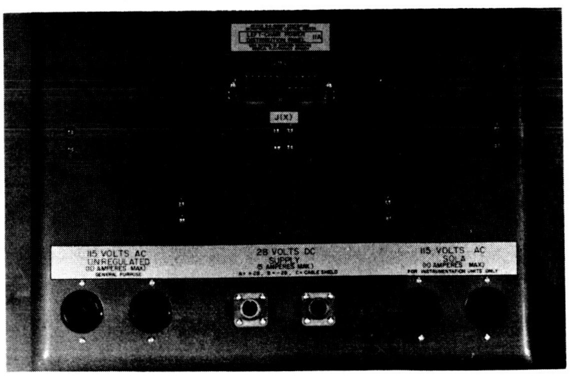

Figure 11

Photograph of the Left-Chair Power Distribution Panel used to supply power and control services to the left experimental area of the device. Units with identical connectors are also installed in the right experimental area and inside the SRR-I enclosure to provide similar services to these areas.

camera with a remotely controlled zoomar lens serves as the on-board video source. This lightweight miniaturized camera can be powered from either a 24 VDC or a 115 VAC source and will operate in an environment with ambient temperature extremes between -20 and +50 degrees Celsius, relative humidities up to 95 per cent, acoustical noise fields to 140 decibels sound pressure level, and linear acceleration fields to 30 g. The blank panel space available below the Rack 2 television monitor is used to house equipments constructed or utilized for a specific experiment.

At the top of Rack 3 may be seen the oscilloscope and the dual audio frequency voltmeter-oscillator combination used for the test, calibration, and maintenance of the over-all system. Immediately beneath is a two channel audio frequency magnetic tape recorder/reproducer which is used either to record voice communication data during an experiment or to reproduce pre-recorded acoustic stimulus signals. A single channel power amplifier installed below this unit serves as an auxiliary monitor. At the bottom of the rack may be seen the two identical two-channel audio frequency power amplifiers used to establish communications between the drive, control, and on-board areas of the installation. Low-impedance dynamic microphones are installed in the control room at the Operator's Console, Monitor's Desk, and Rack 3 stations. Since the on-board microphones are operated in an open or live mode to permit continuous monitoring of on-board conversations by the control area personnel, the control room microphones employ press-to-talk switches to activate relay circuits which mute the loudspeakers in this area, and thus prevent acoustic feedback.

The microphones and loudspeakers installed in the drive and control areas along with the input and output circuitry of all the amplifiers and instruments installed in Rack 3 are terminated at the rear of the Control Room Data Patch Panel installed in Rack 4. The patch panel proper is composed of 391 individually color-coded and shielded nylon circuit cells arranged in a 17x23 matrix which may be interconnected by means of shielded patchcords. The circuits terminated at this unit are shown in pictorial schematic form by Figure 12 which is a front view of the patch-panel matrix. Seventeen of the Slip Ring Set C circuits are terminated by the cells bounded by I1, I17, J1, and J17 with the 18th circuit used as a grounding point for the shields of the related 17 interconnecting coaxial cables. To provide multi-point access to each slip ring, adjacent cells are paralleled by means of rear panel solder jumpers; i.e. slip ring 1 is available on either I1 or J1, slip ring 2 on either I2 or J2, et cetera. Similar termination for Slip Ring Set D is provided by the 01, P1, 017, and P17 cell group.

To record the data signals transmitted over these slip-ring circuits, the differential input circuitry of the eight-channel direct writing recorder installed in Rack 5 is made available in the cell group bounded by R1, T1, R8, and T8; sixteen galvanometers of the 24-channel light-beam recorder installed in Rack 4 are similarly terminated in the cell group defined by U1, W1, U16, and W16; and the differential

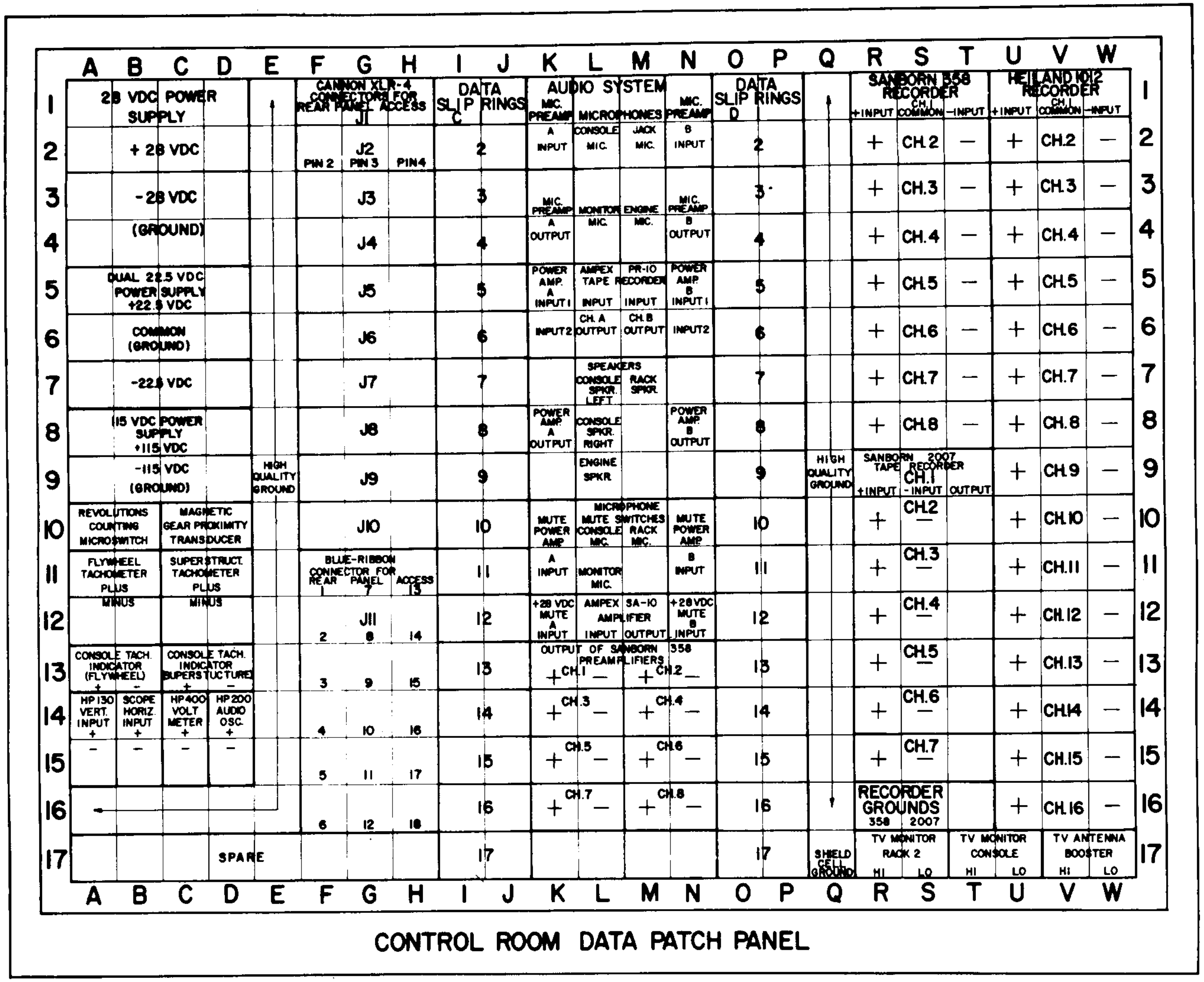

Figure 12

Pictorial schematic of the Control Room Data Patch Panel showing the circuitry terminated at the individually shielded cell blocks.

input circuitry of the seven record channels of the magnetic tape instrumentation recorder, installed in Rack 6, are made available in the R9, S9, R15, and S15 cell group with the single ended outputs of the seven reproduce channels terminated on T9 through T15. By having independent access to each recording channel, as well as a choice of display polarity, the system may be rapidly set up and checked out for each new instrumentation application.

To allow the angular velocity components of the device to be recorded simultaneously with the data derived from on-board measurements, the output lines of the superstructure and flywheel tachometers are also brought to this patch panel. The differential output signals from the plug-in preamplifiers installed in the eight-channel recorder are routed to the patch panel at cell group K13, N13, K16, and N16 so that additional signal-conditioning operations may be performed on the displayed data. These lines also permit the tape recorder to be driven directly without the need for additional amplification. Other equipments terminated at this unit include all of the DC power supplies, the vertical and horizontal amplifiers of the monitor oscilloscope, the input to the AF vacuum tube voltmeter, the output of the AF oscillator, the input video lines to the closed-circuit television monitors, and all of the audio circuitry. Additional access to these circuits is provided by connectors mounted at the rear of the patch panel which may be used to terminate equipments custom-selected for a given experiment.

For on-board electrical access to these control room equipments and circuits, the two sets of data slip rings are similarly terminated at the On-Board Data Patch Panel which is installed on the center column of the device. A photograph of this unit is shown in Figure 13. The patch panel proper is identical to that installed in the control area except for the color code of the individual nylon cells and their circuit assignments. These assignments are shown in pictorial schematic form by Figure 14. The connectors mounted on the front panel of this unit are terminated by the cells bounded by K1, N1, and K12, and N12. These connectors provide the experimenters working in the SRR-1 area with direct access to the patch panel so that the outputs of their custom-selected on-board signal-conditioning equipments can be routed to the control room for graphic display or electrical storage.

To provide the same type of access at each of the outboard experimental areas, data distribution panels have been installed at the left and right chair positions. A photograph of the Left-Chair Data Distribution Panel is shown in Figure 15. The physical configuration of these connectors is identical to that used for the On-Board Data Patch Panel connectors with each contact separately terminated at the patch panel proper. For the left experimental area, these connectors are available in the cell group identified by E1, H1, E12, and H12. Circuits from an identical Right-Chair Data Distribution Panel are similarly terminated in the Q1, T1, Q12, and T12 cell group.

This arrangement allows the operation of any equipment wired for use in one experimental area to be used in any other area without any circuit changes other than the reassignment of patchcord jumpers. The resultant experimental flexibility and ease of maintenance afforded by both the patch-panel approach and the various data and power access or termination panels is obvious. The design philosophy for the entire system follows that which was developed for the Human Disorientation Device Bioinstrumentation Control Center which has been described previously (2).

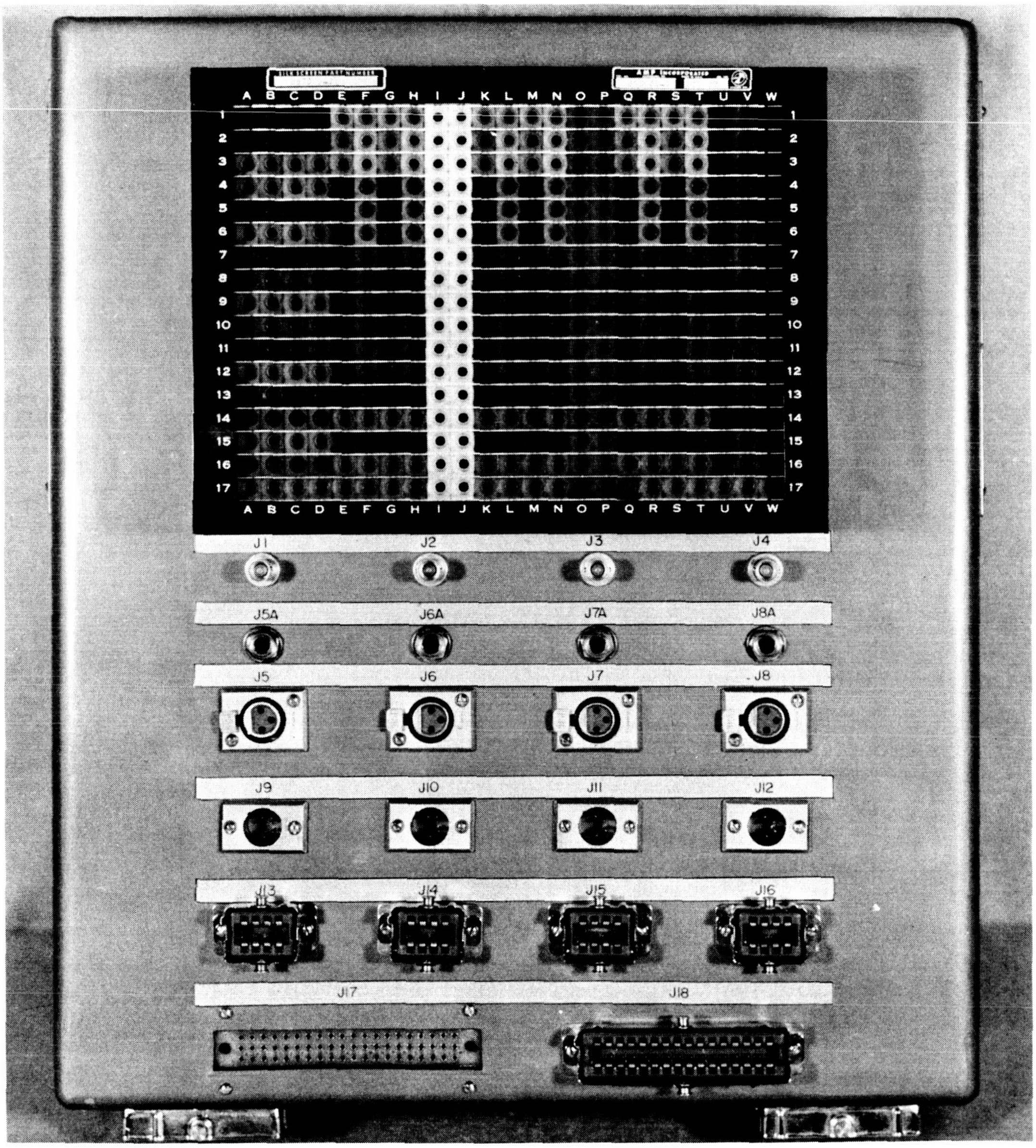

Figure 13

Photograph of the On-Board Data Patch Panel and its front panel access connectors.

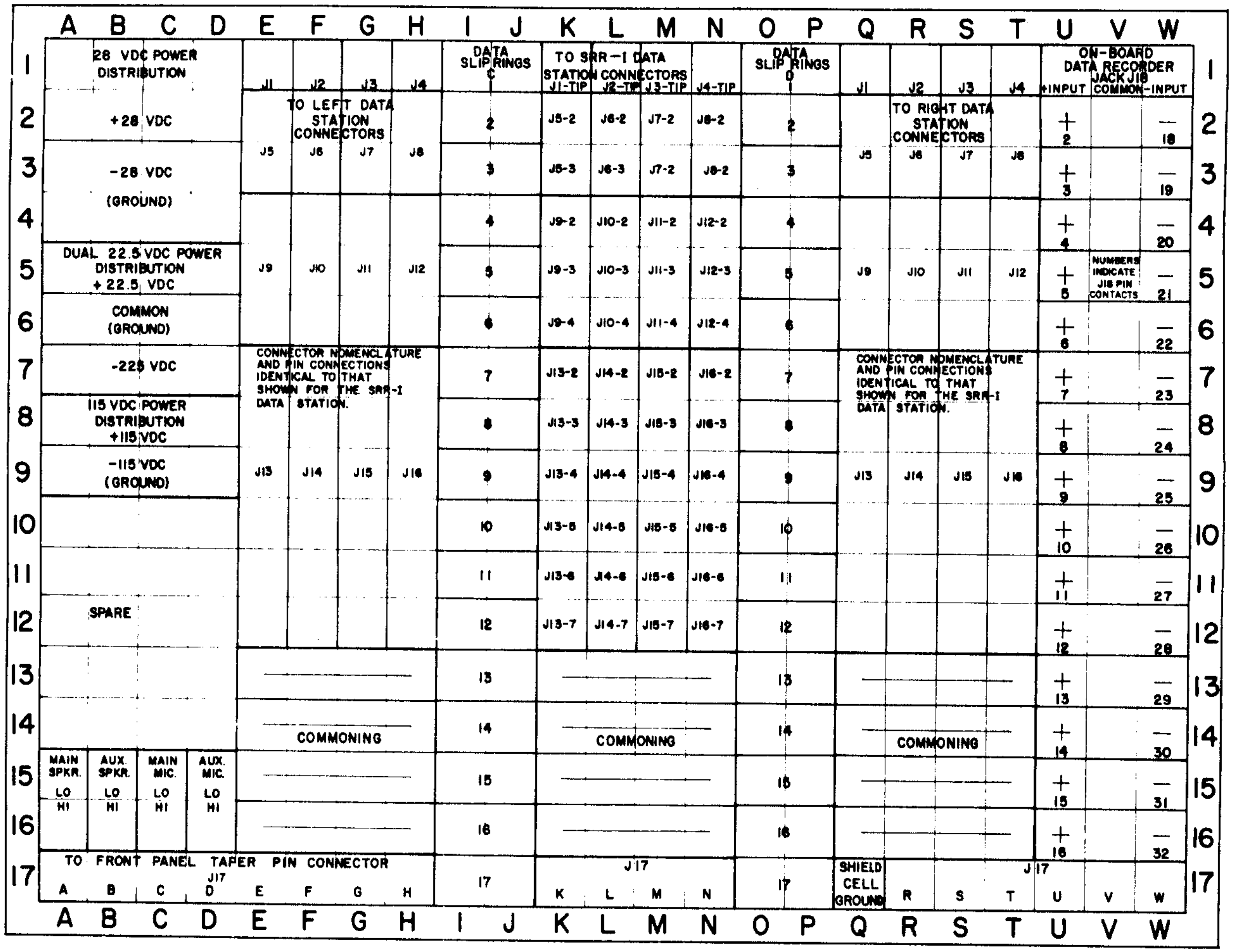

Figure 14

Pictorial view of the front panel of the On-Board Data Patch Panel showing the cell terminations of the basic circuitry.

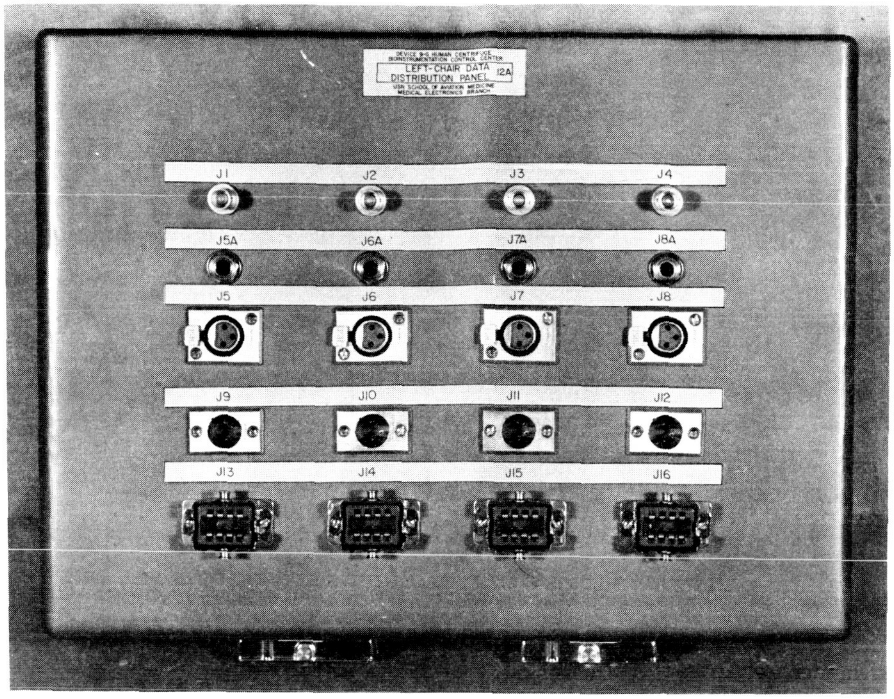

Figure 15

Photograph of the Data Distribution Panel installed in the left experimental area of the device. The layout of the access connectors and their related patch-panel terminations are similar to those provided in the right experimental area and at the Data Patch Panel located inside the SRR-I enclosure.

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